Indian Journal of Agronomy **45** (1) : 31–36 (March 2000)

Response of *gobhi sarson (Brassica napus* subsp. *oleifera* var. *annua)*–soybean (*Glycine max*) sequence to phosphorus and sulphur

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Received: November 1998

ABSTRACT

An experiment was conducted during 1993–94 and 1994–95 to study effect of P levels (0, 30, 60 and 90 kg P_2O_5/ha), and patterns of its application (residual, direct and cumulative) in combination with sulphur (0, 20 and 40 kg S/ha) on *gobhi sarson* [*Brassica napus* (L.) subsp. *oleifera* D.C. var. *annua* L.] and soybean [*Glycine max* (L.) Merr.] cropping sequence at Ludhiana. Both *gobhi sarson* as well as soybean responded to direct application of P up to 60 kg P_2O_5/ha. Both the crops grown on residual phosphorus yielded significantly less as compared to direct application of P. Total productivity of *gobhi sarson*–soybean cropping system was also higher when both the crops were directly fertilized with P @ 60 kg P_2O_5/ha. Application of P to soybean alone in the system gave higher agronomic efficiency than its application to *gobhi sarson.* Application of 60 kg P_2O_5/ha to either of the crops gave lower physiological efficiency than application of 30+30 kg P_2O_5/ha to both the crops. Both crops responded to sulphur application only up to 20 kg/ha.

Key words : *Gobhi sarson*–soybean sequence, P, S, Yield

Swederape (*gobhi sarson)* and soybean, which fit well in the cropping sequence under the Punjab conditions, offer a good scope for meeting the shortage of protein and oilseeds in the country. For improving the productivity of these crops, the role of phosphorus and sulphur is well known. However, P requirement of *gobhi sarson* and soybean has earlier been worked out on the basis of their response to applied P to either of the crops rather than taking into account total P applied to the system as a whole (Sardana, 1990; Kumar *et al.*, 1992). It was, therefore, considered necessary to work out the efficiency with which these crops grown in a sequence utilize the applied P to provide profitable yields.

The response of these crops to applied S may also be modified in relation to level and pattern of P applications (Saran and Giri, 1990; Mahal, 1990). Therefore, the present investigation was conducted to evaluate the response of *gobhi sarson*–

soybean cropping system to P in combination with sulphur.

MATERIALS AND METHODS

The experiment was conducted during 1993–94 and 1994–95 at Punjab Agricultural University, Ludhiana. The soil was loamy sand, normal in pH (7.9) and EC (0.21 mmhos cm), low in organic carbon (0.36%) and available nitrogen (176 kg/ha), medium available P (14 kg/ha), K (237 kg/ha) and sulphur (11 ppm). The experiment was laid out in split/plot design with 4 replications. Three levels of phosphorus (30,60 and 90 kg P_2O_5/ha), 3 patterns of P application (residual, direct and cumulative) along with 1 unmanured control (no P) were kept in main plots and 3 levels of sulphur, i.e. 0, 20 and 40 kg S/ha, in subplots. Net plot size was 5.0 m × 2.7 m for *gobhi sarson* and 5.0 m × 2.25 m for soybean. Direct application of P to 1 crop became residual treatment for succeeding crop. In cumulative pattern of application, P was applied to both the crops. Varieties 'GSL 1' of *gobhi sarson* and 'PK 416' of soybean were raised for experimental purpose.

To determine the P and S content, the plant samples collected for dry-matter accumulation at different intervals were used. The content was determined by vanadomolybdo phosphoric yellow colour method in nitric acid system (Jackson, 1967) using spectronic–20 colorimeter at a wave-length of 470 mμ using blue filter. Sulphur content in the plant extract was determined turbidimetrically in an aliquot by spectronic-20 colorimeter at a wave/length of 420 mμ using blue filter. Total uptake of P and S was worked out at harvest by multiplying respective per cent contents with the dry matter.

Total productivity in terms of *gobhi* sarson-equivalent yield was calculated. Agronomic and physiological efficiencies were calculated as per the procedure given by Craswell and Godwin (1984) and also cited by Bisht and Chandel (1991).

RESULTS AND DISCUSSION

In a soil, testing medium in available P, soybean and *gobhi sarson* responded significantly to P application only up to 60 kg P_2O_5/ha (Table 1). Direct application of P to *gobhi sarson* or soybean in the system benefited the crop significantly as compared to those raised on residual P, whereas the responses to direct and cumulative patterns of P application were found statistically similar. However, the interaction between the levels and patterns of application, in both the crops, was non-significant. Response of *gobhi sarson* to phosphate fertilization was as high as 120-180 kg P_2O_5/ha in Poland (Dembinski *et al.*, 1969; Horodyski and Pieckza, 1970). Similarly, in soybean–wheat sequence Kalinina (1980) and Griffin *et al.* (1981) observed that direct application of P to soybean yielded higher than that grown on residual P. Likewise, total productivity of the system in terms of equivalent yield of *gobhi sarson* where P @ 60 kg P_2O_5/ha was applied to *gobhi sarson* or to soybean remained the same. Thus productivity of the system increased considerably up to 60 kg P_2O_5/ha when applied to both the crops in the system during both the years, as further increment of P level to 90 kg P_2O_5/ha failed to affect the

Table 1. Effect of levels and patterns of phosphorus application and sulphur levels on seed yield and nutrient removal of *gobhi sarson* and soybean

Treatment	Seed yield (q/ha)				Nutrient removal by crops (kg/ha)							
	Gobhi sarson		Soybean		Phosphorus (P_2O_5)				Sulphur (S)			
	1993–94	1994–95	1993–94	1994–95	*Gobhi sarson*		Soybean		*Gobhi sarson*		Soybean	
					1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95
P_2O_5 (kg/ha)												
Control (P_o)	9.7	9.5	11.6	11.1	7.6	7.6	12.3	11.5	12.4	11.0	8.1	7.2
30	11.7	12.9	13.9	14.5	11.2	12.8	17.3	18.1	18.8	19.5	11.3	10.3
60	13.1	14.2	15.3	17.0	15.2	16.2	22.8	24.2	23.4	23.2	15.0	14.2
90	13.2	14.5	15.7	17.3	16.2	17.3	25.3	26.6	25.1	23.4	17.1	15.6
CD (P = 0.05)*	0.9	1.1	1.1	1.6	2.8	3.2	3.7	4.0	3.4	2.9	2.6	2.2
P application pattern												
Residual	11.4	12.6	13.3	14.7	11.5	12.6	17.5	18.2	18.4	19.0	11.9	11.0
Direct	13.2	14.0	15.6	16.6	14.8	15.7	22.5	24.0	23.8	22.8	15.1	14.5
Cummulative	13.4	15.0	16.0	17.5	16.2	18.0	25.5	26.7	25.1	24.4	16.4	14.6
CD (P = 0.05)	0.9	1.1	1.1	1.6	2.8	3.2	3.7	4.0	3.4	2.9	2.6	2.2
Sulphur (kg/ha)												
Control (S_o)	10.9	11.8	13.9	15.0	12.0	12.0	18.7	21.3	17.0	18.5	10.0	11.4
20	13.4	14.8	15.4	16.8	14.6	16.0	22.5	24.6	24.0	23.0	15.3	13.8
40	13.8	14.9	15.7	17.3	15.9	17.6	24.2	27.2	26.2	23.5	18.1	14.6
CD (P = 0.05)	1.2	1.0	1.4	1.7	NS	NS	NS	NS	5.2	2.1	3.5	1.3

*This CD is applicable for comparison within the levels of phosphorus only.

productivity of the system. But, as mentioned earlier, different interaction effects were found to be non-significant. Better response of both these crops in terms of enhanced yield with direct application of P could be attributed to adequate direct supply of P. Hence in *gobhi sarson*–soybean cropping system, both crops require direct application of P (60 kg P_2O_5/ha) for attaining optimal productivity level.

Sulphur application @ 20 kg/ha to both the crops proved better than no sulphur application, but the total productivity of the system @ 40 kg S/ha was similar to 20 kg S/ha. The interaction between levels and patterns of P application and S levels was also non-significant.

Application of P @ 60 kg P_2O_5/ha to soybean in the system gave better efficiency than its application to *gobhi sarson,* as the application of 90 kg P_2O_5/ha to *gobhi sarson* or to soybean was on a par with 60 kg P_2O_5/ha applied to both the crops in the system (Table 2).

The agronomic efficiency was considerably higher at lower rates of P application and it decreased with an increase in the level of P applied (Table 2). Direct application of P to *gobhi sarson* or to soybean in the system at all the levels of P application gave higher agronomic efficiency than the crop grown on residual P. Application of P to soybean alone in the system at all levels of P gave higher agronomic efficiency than its application to *gobhi sarson* in the system. Application of 90 kg P_2O_5/ha to *gobhi sarson* or soybean was at par with 60 kg P_2O_5/ha applied to both the crops, i.e. 120 kg P_2O_5/ha, to the system. Further increase in the P_2O_5 rate to both the crops did not help in enhancing the agronomic efficiency of the system. Agronomic efficiency was the highest with the lower dose of S application than its higher dose applied to both the crops.

The physiological efficiency was highest when P was applied @ 30 kg P_2O_5/ha to *gobhi sarson* and the succeeding crop of soybean was raised on residual P (Table 2). Similar trend was observed at 60 kg P_2O_5/ha, but with a decline in the efficiency. However, when 60 kg P_2O_5/ha was applied to any of the 2 crops, the physiological efficiency was lower than the application of 30+30 kg P_2O_5/ha applied to both the crops in the system during both the years. Application of 60 or 90 kg P_2O_5/ha to both the crops in the system also resulted in lower physiological efficiency than the application of P to individual crop. Physiological efficiency was highest with S application up to 20 kg/ha than 40 kg/ha applied to both the crops in the system.

Nutrient removal

Total P and S removal increased with the increasing levels of P application both in *gobhi sarson* and soybean (Table 1), but the response was pronounced only up to 60 kg P_2O_5/ha. Increased P and S uptake with P application may be associated with higher biomass production and development of extensive and deep root system to trap more area for nutrient supply. Application of P to both the crops either at 60 + 60 or 90 + 90 P_2O_5/ha resulted in more removal of P as well as S than P application to either of the crops in the system.

Application of S at 20 or 40 kg/ha increased the S uptake considerably as

Table 2. Total productivity, agronomic efficiency and physiological efficiency of *gobhi sarson* and soybean as influenced by levels and patterns of phosphorus application and sulphur levels

Treatment		Total productivity as *gobhi sarson* equivalent (q/ha)		Agronomic efficiency (kg grain/kg nutrient applied)						Physiological efficiency (kg grain/kg P removed)					
Gobhi sarson	Soybean			*Gobhi sarson*		Soybean		Total		*Gobhi sarson*		Soybean		Total	
		1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95	1993–94	1994–95
P (kg P_2O_5/ha)															
0	0	19.0	18.4												
0	30	23.0	23.9	5.5	7.3	9.8	13.7	15.3	21.0	68.5	75.9	53.0	46.6	121.5	122.5
0	60	24.4	26.8	2.9	5.8	7.8	10.3	10.7	16.1	39.6	61.4	48.4	45.3	88.0	106.7
0	90	24.5	27.0	2.0	4.0	5.1	7.0	7.1	11.0	36.7	57.1	29.9	41.7	66.6	98.9
30	0	21.6	23.3	6.5	12.0	2.7	5.6	9.2	17.6	56.7	66.6	49.1	73.9	106.8	140.5
60	0	24.4	26.3	6.9	7.6	2.5	7.0	9.4	14.6	49.2	53.5	25.3	56.0	74.5	109.5
90	0	25.5	27.5	4.7	5.8	3.2	5.4	7.9	11.2	43.8	51.0	37.2	48.0	81.0	99.0
30	30	24.1	26.4	4.1	7.3	5.5	7.5	9.6	14.8	50.5	60.3	41.9	51.7	92.4	112.0
60	60	27.1	30.4	3.6	5.1	4.0	6.2	7.6	11.3	43.1	53.5	31.7	43.8	74.8	97.3
90	90	27.4	30.5	2.4	3.4	2.8	4.2	5.2	7.6	39.1	49.6	30.5	37.3	69.6	86.9
S (kg S/ha)															
0	0	22.0	23.8												
20	20	25.7	28.2	6.2	7.5	3.8	4.0	10.0	11.5	96.2	65.2	39.5	54.5	135.6	119.8
40	40	26.4	28.6	3.6	3.9	2.3	2.6	5.9	6.5	74.4	55.4	32.7	35.6	107.1	91.0

compared to P uptake in *gobhi sarson* and soybean during both the years.

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